

Period-Luminosity Relations For Magellanic Clouds Cepheids Based on OGLE-III Data: A Comparison

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Abstract.

The period-luminosity (P-L) relation for Cepheid variables is important in modern astrophysics. In this work, we present the multi-band P-L relations derived from the Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC) Cepheids, based on the latest release of OGLE-III catalogs. In addition to the *VI* band mean magnitudes adopted from OGLE-III catalogs, we also cross-matched the LMC and SMC Cepheids to the 2MASS point source catalogs and publicly available *Spitzer* catalogs from SAGE program. Mean magnitudes for these Cepheids were corrected for extinction using available extinction maps. When comparing the P-L slopes, we found that the P-L slopes in these two galaxies are consistent with each others within $\sim 2.5\sigma$ level.

1. Introduction

The period-luminosity (P-L, also known as Leavitt Law) relation for Cepheid variables is important in modern astrophysics, as it is the first rung in the distance scale ladder. The P-L relations can also be used to constrain the theoretical PL relations based on stellar pulsation and evolution models. One important issue in the application of P-L relation in distance scale work is its universality – is the slope of P-L relation independent of metallicity? In this work, the multi-band P-L relations were derived for the Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC) Cepheids, based on the latest release of OGLE-III (the third phase of Optical Gravitational Lensing Experiment) catalogs. Large numbers ($\sim 10^3$) of Cepheids in the LMC and SMC permit the determination of accurate P-L slopes, hence testing the universality of the P-L relation in low metallicity galaxies.

2. Data and Methods

Periods and intensity mean magnitudes in *VI* bands were available from OGLE-III catalogs for ~ 1800 LMC Cepheids [5] and ~ 2600 SMC Cepheids [6]. All of these Cepheids are fundamental mode Cepheids. SMC Cepheids with $\log(P) < 0.4$, however, were removed from the sample, as they followed different P-L relation [1]. These Cepheids were cross-matched to 2MASS point

Table 1. Slopes of the P-L Relations.

Band	LMC P-L Slopes	SMC P-L Slopes	Slope Difference
<i>V</i>	-2.769 ± 0.023	-2.672 ± 0.036	0.097 ± 0.043
<i>I</i>	-2.961 ± 0.015	-2.926 ± 0.028	0.035 ± 0.032
<i>J</i>	-3.115 ± 0.014	-3.062 ± 0.024	0.053 ± 0.028
<i>H</i>	-3.206 ± 0.013	-3.171 ± 0.023	0.035 ± 0.026
<i>K</i>	-3.194 ± 0.015	-3.231 ± 0.039	0.037 ± 0.038
$3.6\mu\text{m}$	-3.253 ± 0.010	-3.226 ± 0.019	0.027 ± 0.021
$4.5\mu\text{m}$	-3.214 ± 0.010	-3.184 ± 0.020	0.030 ± 0.022
$5.8\mu\text{m}$	-3.182 ± 0.020	-3.235 ± 0.042	0.053 ± 0.047
$8.0\mu\text{m}$	-3.197 ± 0.036	-3.281 ± 0.062	0.084 ± 0.072
<i>W</i>	-3.313 ± 0.008	-3.319 ± 0.018	0.006 ± 0.020

source catalog. The random-phase *JHK* photometry were converted to mean magnitudes using the prescription given in [4]. The mid-infrared photometry were available from *Spitzer* archival data – SAGE [2] and SAGE-SMC. Zaritsky’s extinction maps for LMC [8] and SMC [7] were used for extinction corrections. In addition, the extinction-free P-L relation – the Wesenheit Function in the form of $W = I - 1.55(V - I)$, was also derived. Outliers presented in the P-L plane were removed using an iterative sigma clipping algorithm [3]. Additional period cuts need to be applied in certain bands, as the faint end (hence shorter period) of these P-L relations may be affected by incompleteness bias.

3. Results and Conclusion

Comparison of the multi-band P-L slopes for these two metal poor galaxies are presented in Table 1. Note that the LMC P-L slopes have been published in [3]. As can be seen from this Table, the P-L slopes are within $\sim 2.5\sigma$ in all bands between the LMC and SMC Cepheids. The *W* band P-L slopes are almost identical, suggesting the extinction-free *W* band P-L relation is a good choice for distance scale application.

Acknowledgements

CCN thanks the funding from National Science Council (of Taiwan) under the contract NSC 98-2112-M-008-013-MY3.

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